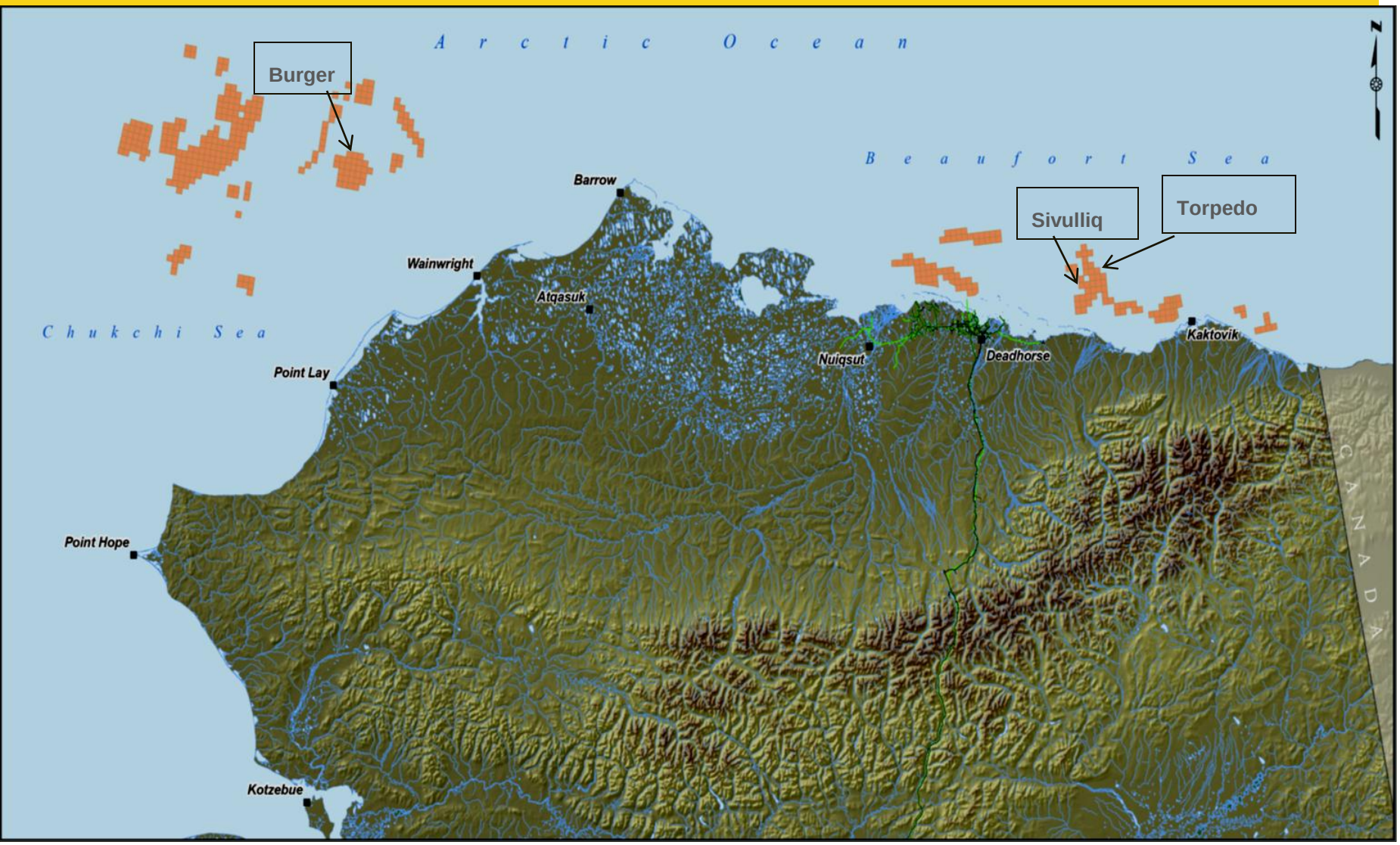
Alaska Science Program Overview

Michael Macrander Science Lead, Shell Alaska

Robert Raye Metocean & Ice

Chukchi and Beaufort Seas



2012-13 Proposed Operations

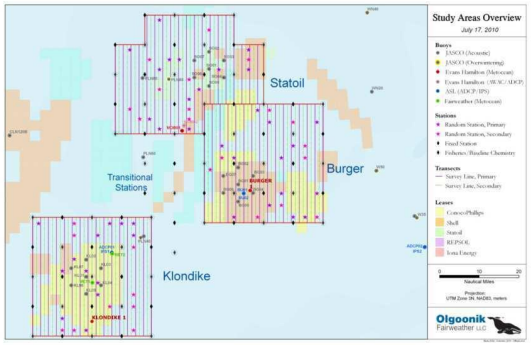
- Drill up to four wells per year in Chukchi Sea during open water drilling season (July-October)
- Drill up to two wells per year in Beaufort Sea during open water drilling season (July-October)

- Continuation of Shell's long-term ecological characterization offshore and onshore
- Continuation of marine mammal monitoring

Alaska Venture Science Studies Program

Monitoring

- Permit driven (compliance)
- Marine Mammal MP
- Threatened & Endangered
- Air

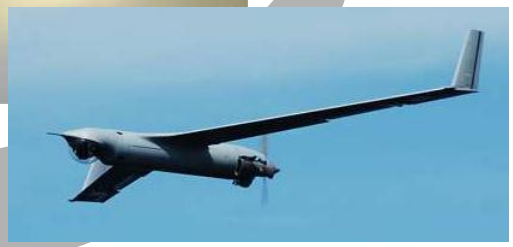


Baseline studies

- Provides basis for project design
- Identifies issues
- Fills data gaps
- Provides basis for NEPA documents (EIS)
- Ecological
- Ice/weather
- Ice gouge / streudel scour / soil testing
- Traditional knowledge

Engineering & Technology

- Enabling both E & P
- Unmanned aerial
- Autonomous underwater
- On-ice seismic
- Sound mitigation
- Ice forces



Criticality of Collaboration

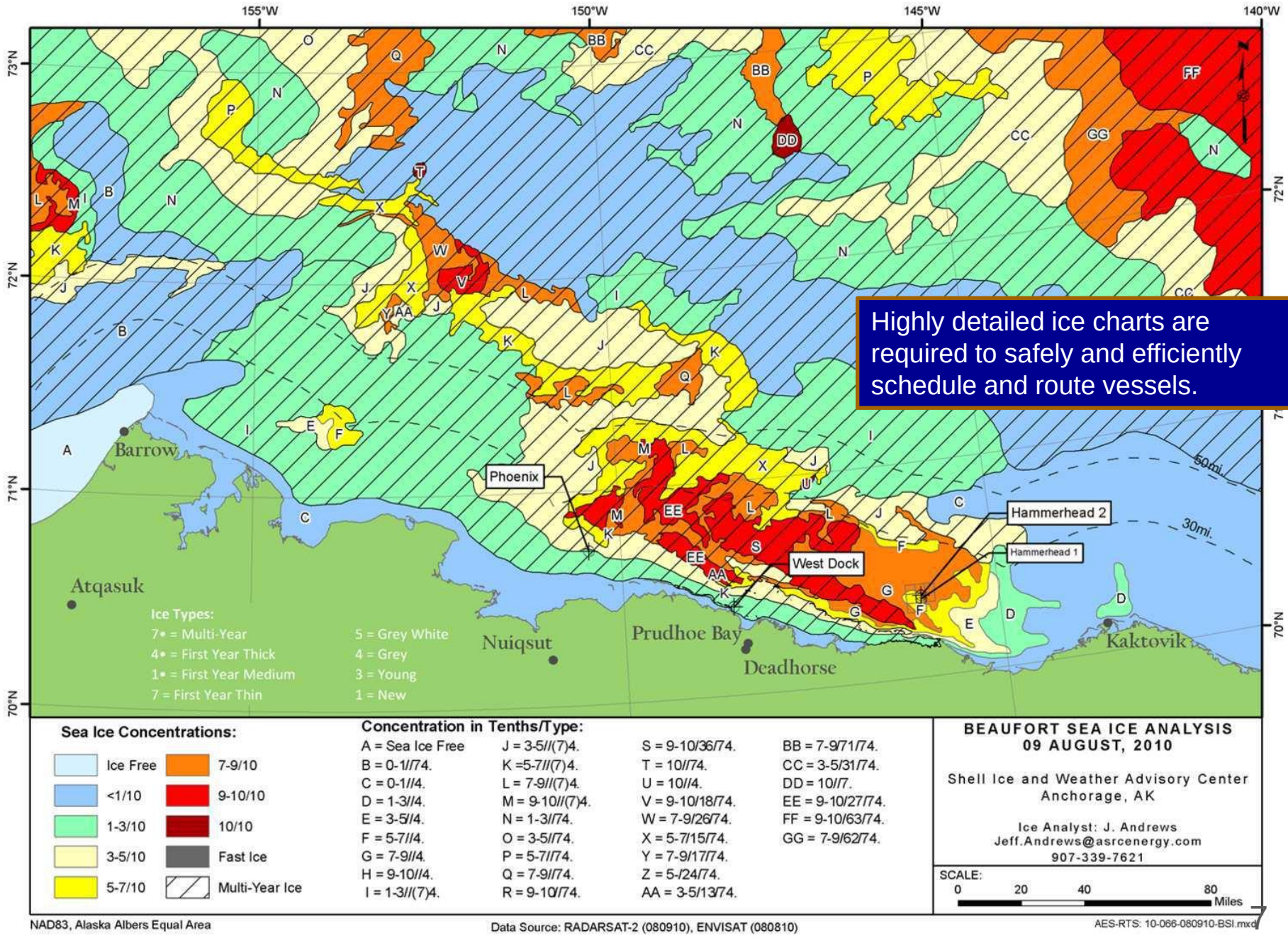
- Much of the information provided is the result of collaborative effort
  - ConocoPhillips has been a key partner
  - Statoil, GXT, Pioneer, & ENI
  - Academic institutions including UAF, UT, UMD, FIT, CU
  - Government entities including USGS, BOEM, NOPP, NOAA
  - Research entities including NFWF, Northern Forum
- Approximately 60 % of Shell funded science is leveraged
- Shell recently signed an agreement with the North Slope Borough to fund and operate a collaborative research effort aimed at enabling local people to answer questions relevant to them

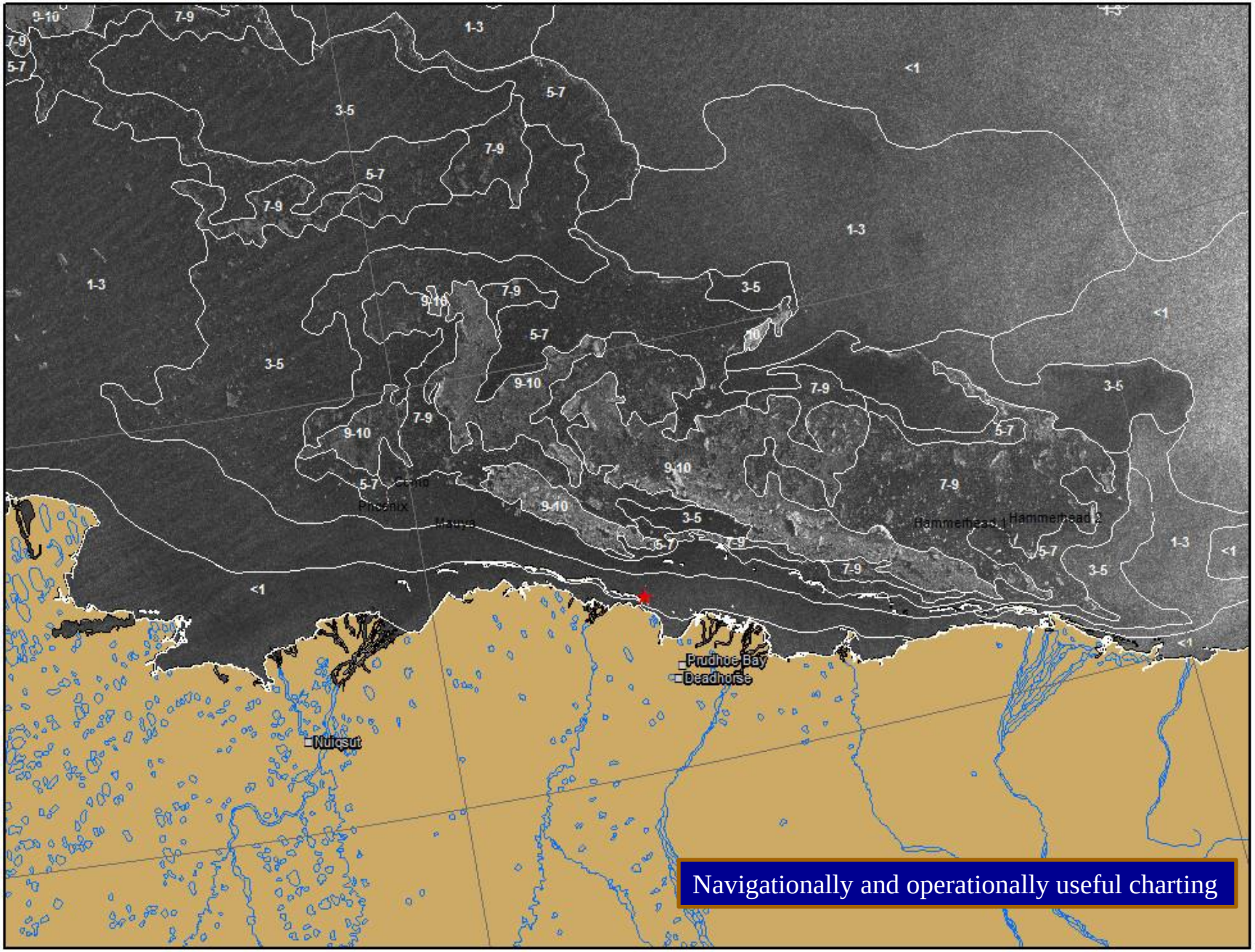
Shell developed and manages a fit-for-purpose operational ice and weather forecasting service to fill the gaps left by commercial and national services.

SIWAC (Shell Ice and Weather Advisory Center) produces **focused and operation-driven forecasts** and provides advisory services for planning managers.

Forecasts are communicated to operations through several methods, including the siwac.com website.

SIWAC daily ice analysis

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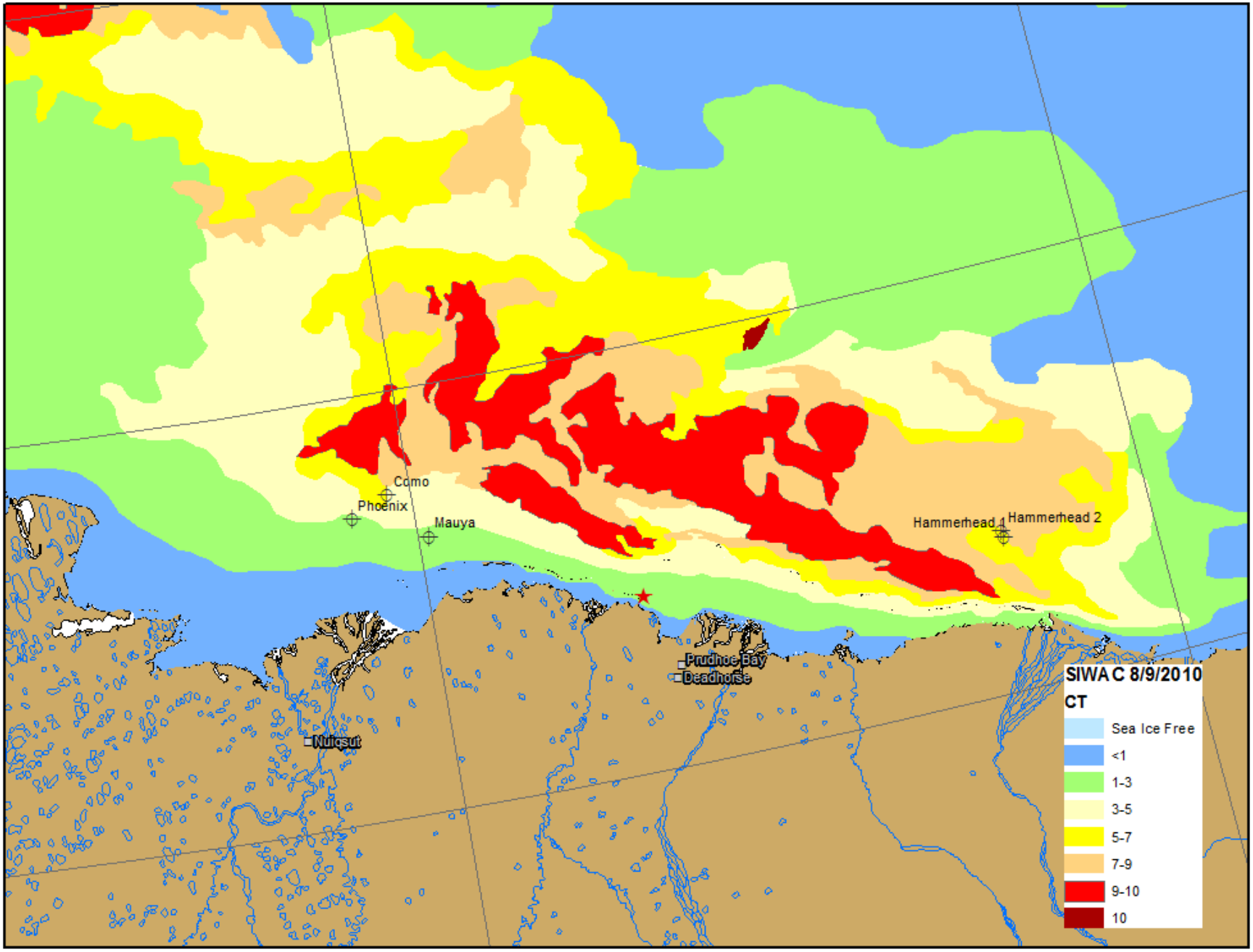
Prudhoe Bay
Deadhorse
Nuiqsut
Hammerhead 1
Hammerhead 2
71° N
70° N
150° W
Navigationally and operationally useful charting


71° N
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Prudhoe Bay
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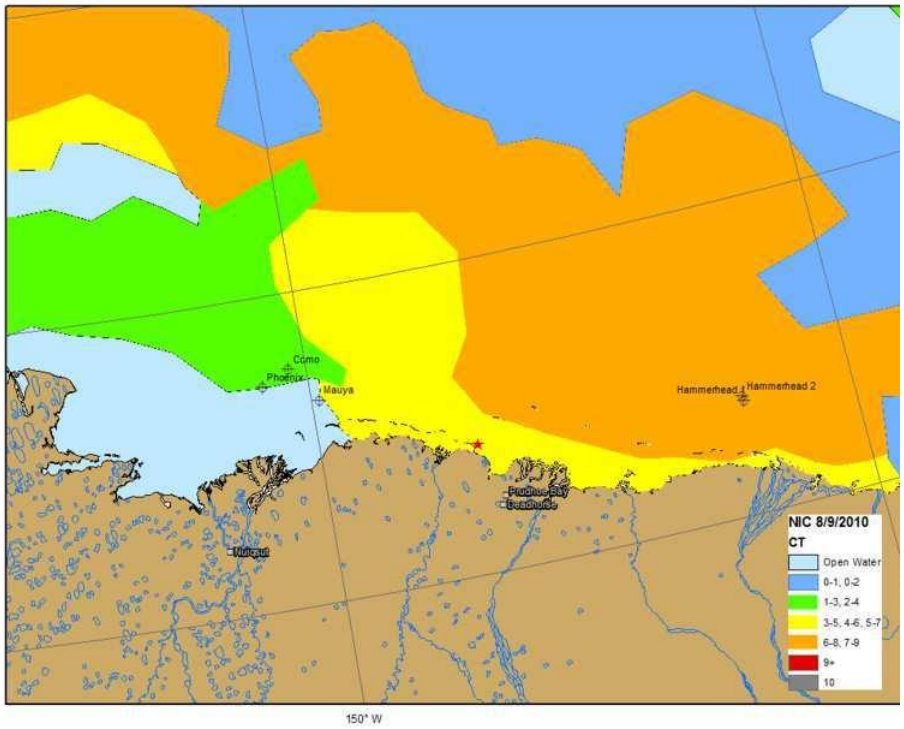
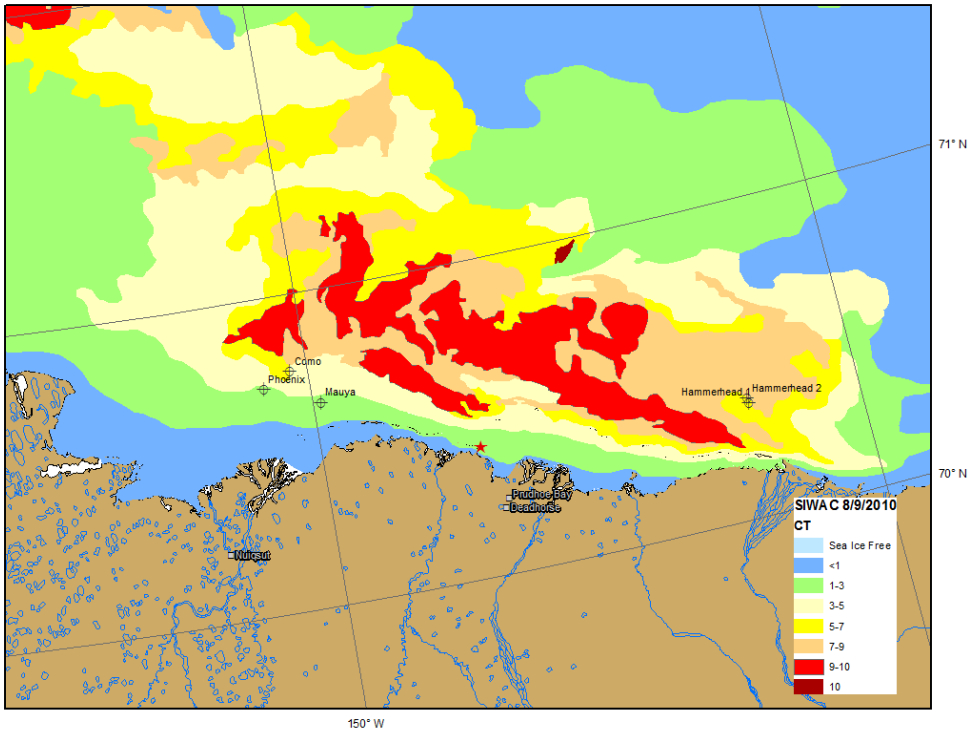
Side by Side Comparison….

Publically available chart from
The NOAA National Ice Center



Highly detailed charts produced by the
Shell Ice and Weather Advisory Center



Seasonal Outlooks

Shell Ice and Weather Advisory Center

Seasonal Outlook for the U.S. Beaufort and Chukchi Seas 2011 Report # 3

Area of Concern	Opening Day	Confidence Level	Verified
Open Water Transit Dutch to Nome	1st Week of June	Moderate to High	1st Week of June
Open Water Transit to Pt Lay to Barrow	End of June to 1st week July	Moderate to High	Pending
Open Water Chukchi Prospects	End of June to 1 July	Moderate to High	2nd week of June 4 of 5 prospects in open water
Open Water Harrison Bay	End of July to 1st week of August	Moderate	Pending
Open Water Sivulliq	Mid July	Moderate	Pending
O/W Transit Barrow to Barter	End of July to 1st Week Aug	Moderate	Pending

ImpactWeather
Your Weather Department

Marine Forecast for Shell Alaska (Burger (71.25N 163.20W))

Issued: 0959 AKDT Monday, September 27, 2010

Discussion: A stalled area of low pressure over the Beaufort Sea will producing increased winds and seas today and tomorrow. Winds and seas will steadily decrease by mid week as the low moves out of the region and high pressure builds back into the region.

Note: All wind speeds are in **knots** 33 feet above sea-level. Wave hei

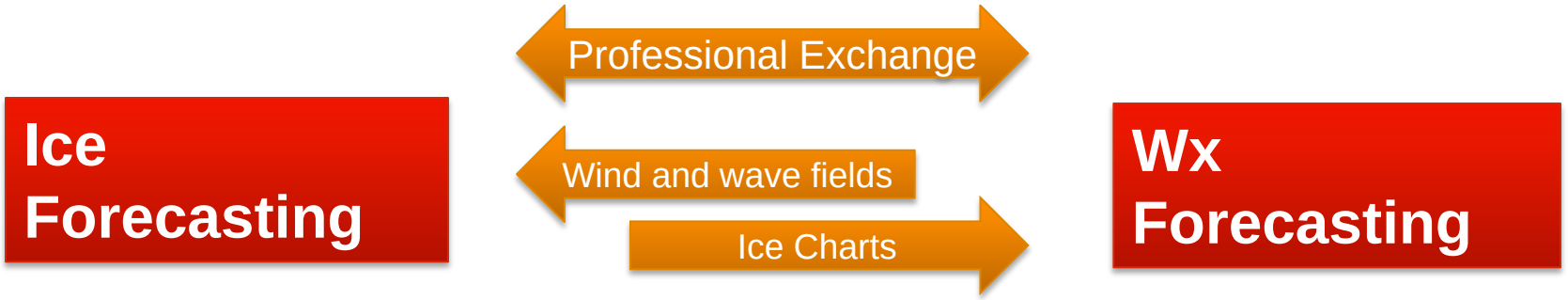
As part of SIWAC, Shell employs full-time professional meteorologists in Anchorage to produce 2x daily weather nowcasts and forecasts and vessel routing guidance.

Valid: Monday, 27 September to Tuesda				
Weather	Mostly cloudy with mixed wintery precipitation.			
Time	**Wind**	**Sea**	**Swell**	**Combined Waves**
1000 AKDT	NW 14-19 G24	4-6 pd 5	NNW 3-5 pd 6	5-7 ocnl 9
1600 AKDT	NW 14-19 G24	4-6 pd 5	NNW 3-5 pd 6	5-7 ocnl 9
2200 AKDT	NW 15-20 G25	4-6 pd 5	NW 3-5 pd 6	5-7 ocnl 9
0400 AKDT	NW 16-21 G26	4-6 pd 5	NW 3-5 pd 7	5-7 ocnl 9

Valid: Tuesday, 28 September to Wednesday, 29 September				
Weather	Mostly cloudy with mixed wintery precipitation.			
Time	**Wind**	**Sea**	**Swell**	**Combined Waves**
1000 AKDT	NW 15-20 G25	4-6 pd 5	NW 4-6 pd 7	6-8 ocnl 11
1600 AKDT	WNW 14-19 G24	4-6 pd 5	NW 4-6 pd 7	6-8 ocnl 11
2200 AKDT	WNW 14-19 G24	4-6 pd 5	NW 4-6 pd 7	6-8 ocnl 11
0400 AKDT	NW 9-14	2-4 pd 4	WNW 3-5 pd 6	4-6 ocnl 8

Valid: Wednesday, 29 September to Thursday, 30 September	
Weather	Mostly cloudy with mixed wintery precipitation.

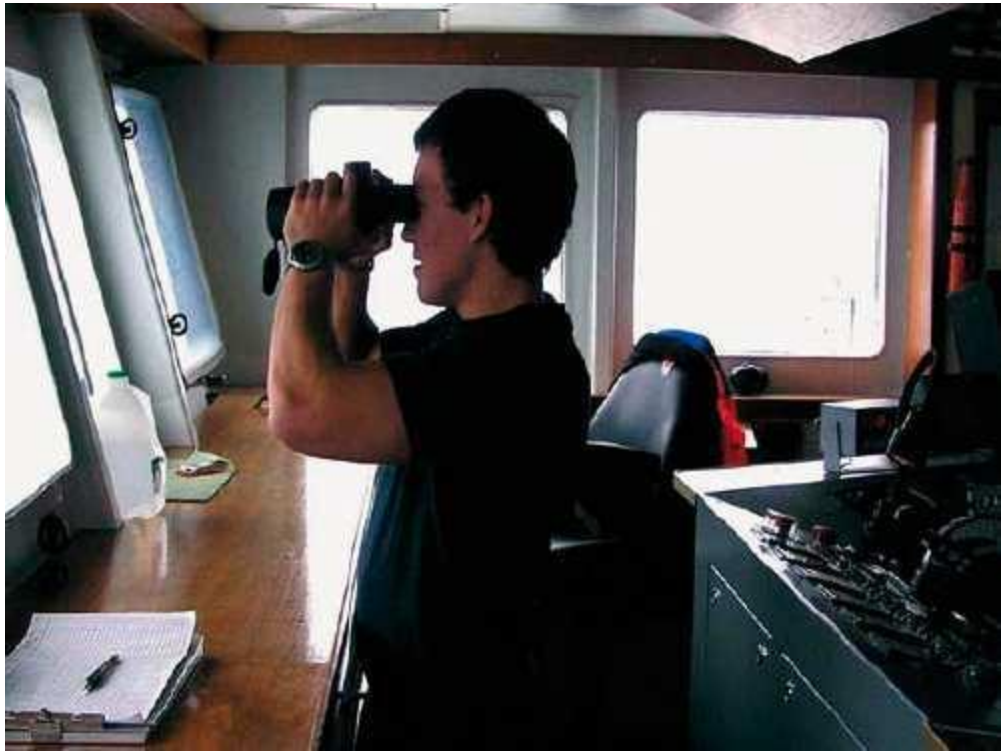
Ice and Weather Together…



A key to a successful Arctic forecasting system is to co-locate the ice and weather specialists so they function as a unit and leverage each other's experience, talents, and work products.

Field Observations

Vessel personnel and Marine Mammal Observers provide ice and weather observations and measurements from the field directly to Shell's forecasters. This feedback loop has resulted in significantly improved forecast quality and a constant source of verification data.

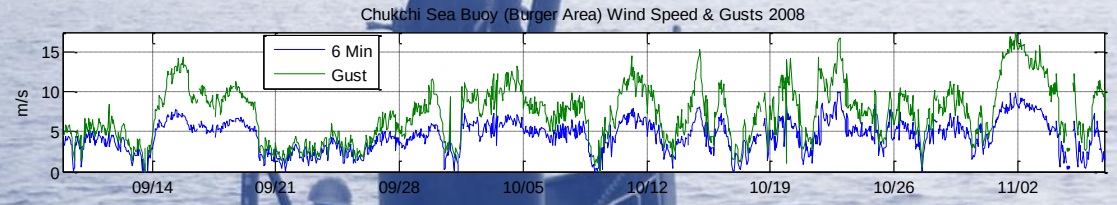


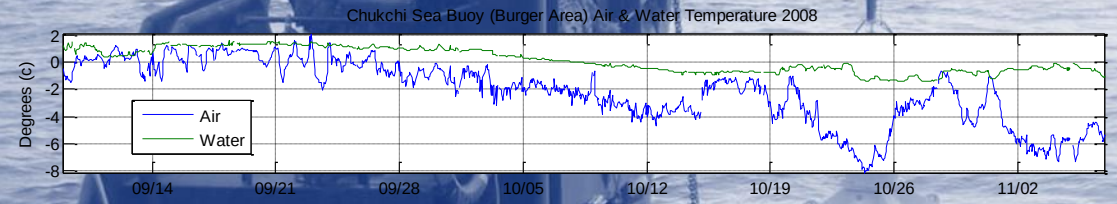
Field Instrumentation

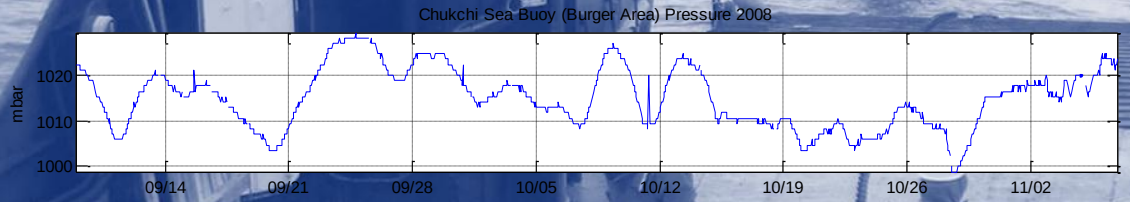
2008
71.51N 164.07W: Burger
2009
71.51N 164.08W: Burger
70.37N 146.04W: Sivulliq
2010
71.51N 164.08W: Burger
70.37N 146.04W: Sivulliq

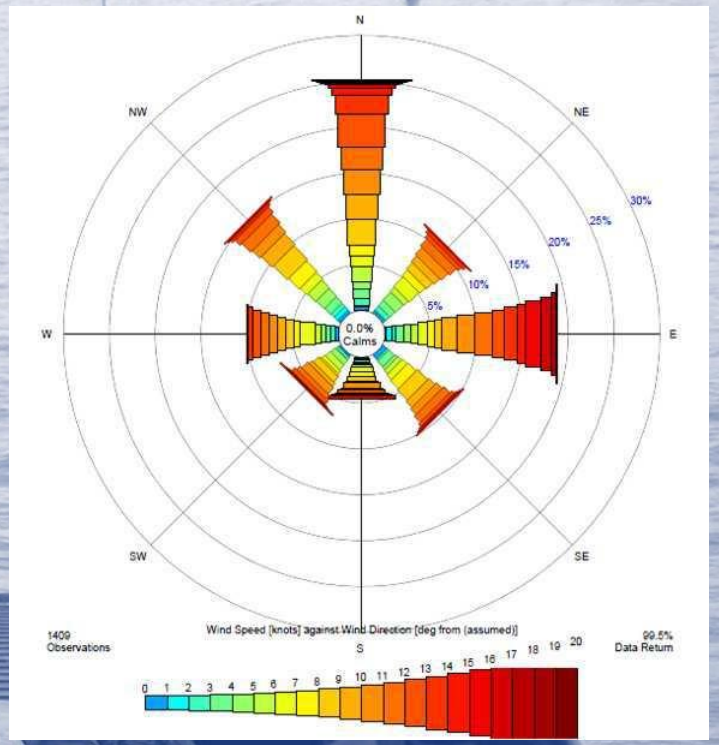
1.8 m meteorological buoy deployed in Chukchi Sea September 2008

Sample data from 2008 Chukchi Sea Meteorological Buoy









Instrumentation

- Wind speed
- Wind direction
- Air temperature
- Water temperature
- Barometric pressure
- Humidity
- Solar intensity

Coastal Met Stations

- Barrow
- Deadhorse
- Kaktovik
- Nuiqsut
- Point Hope
- Point Lay
- Wainwright

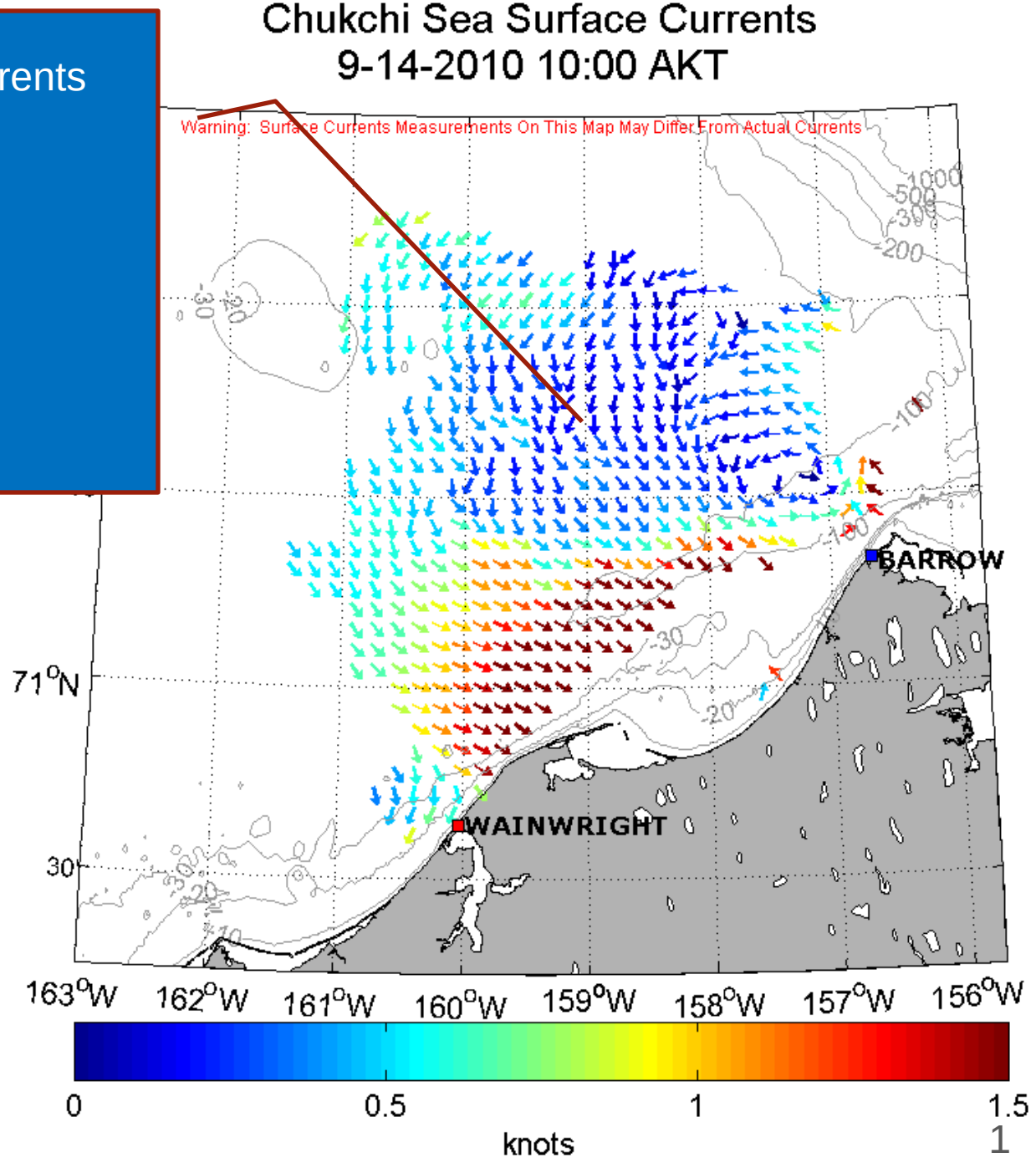
Shell deployed a network of weather stations along the Chukchi and Beaufort coasts in 2008.

Wainwright Com Center Met Station

Chukchi Surface Currents
HF Radar

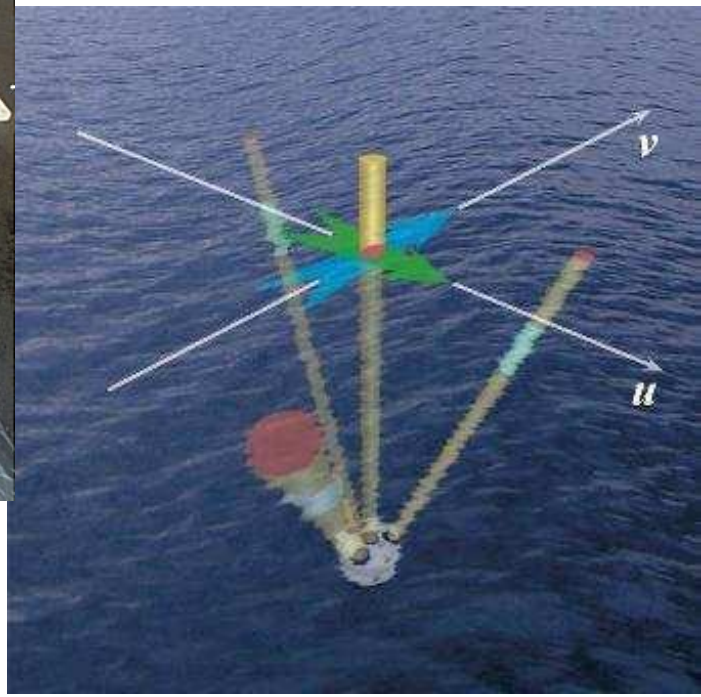
Sponsored by:
BOEMRE
CPAI
Shell

http://www.ims.uaf.edu/hfradar/



AWAC – Acoustic Waves and Current Meter

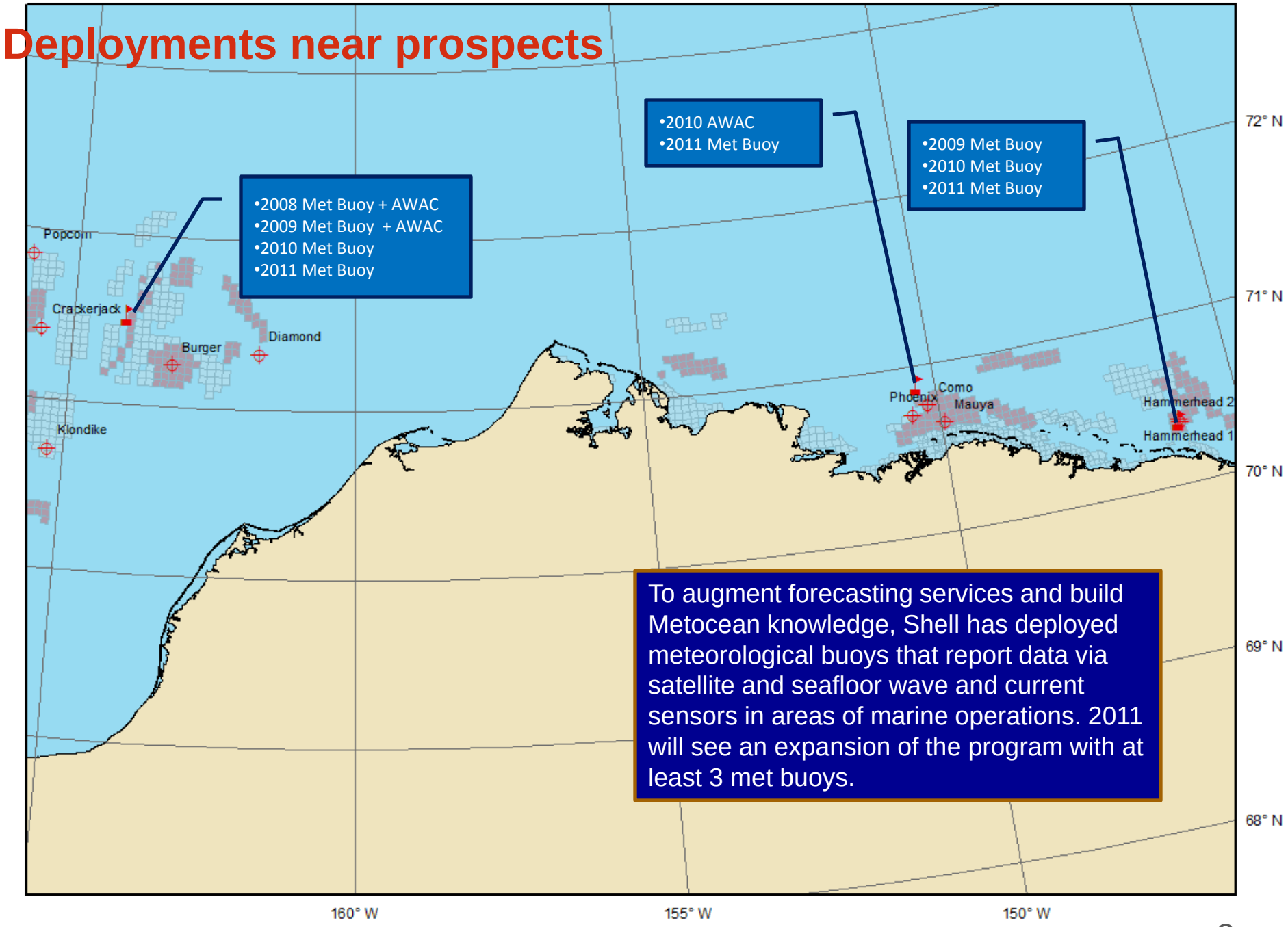
2008
71.51N 164.07W: Burger
2009
71.51N 164.08W: Burger
2010
70.87N 150.27W: Harrison Bay



Measurement Objectives:
- Current Profiles
- Directional Waves
- Ice Keel Measurement (hypothetical)
- Ice Drift Vectors (hypothetical)

Status: Failed Recovery (1x)

Deployments near prospects

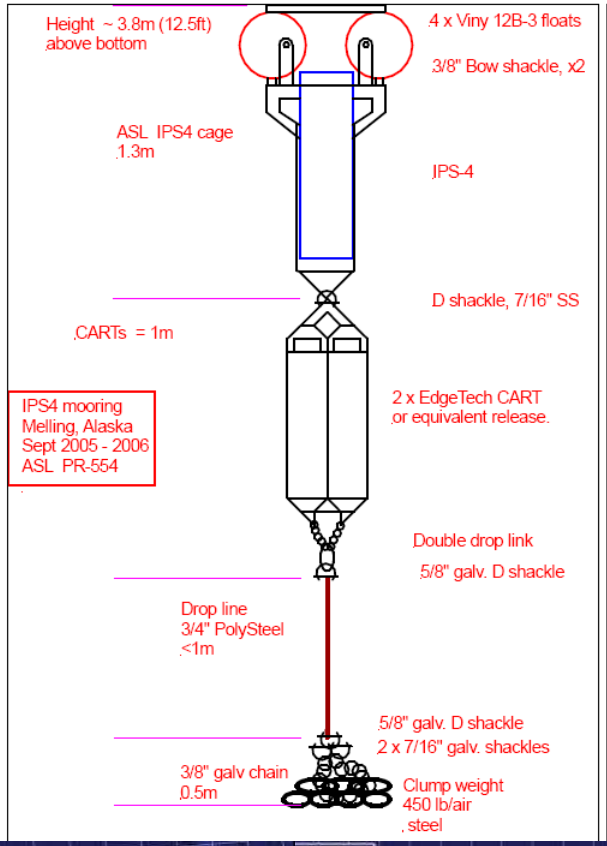


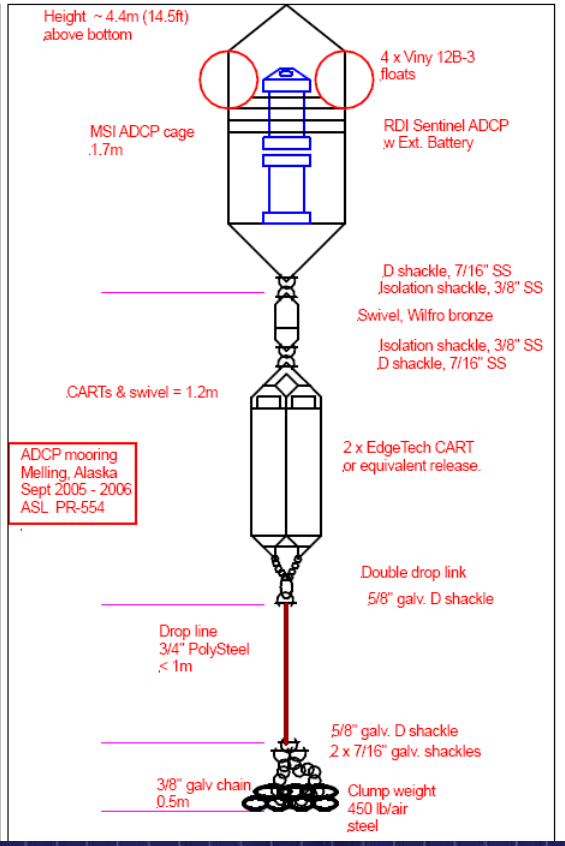
To augment forecasting services and build Metocean knowledge, Shell has deployed meteorological buoys that report data via satellite and seafloor wave and current sensors in areas of marine operations. 2011 will see an expansion of the program with at least 3 met buoys.

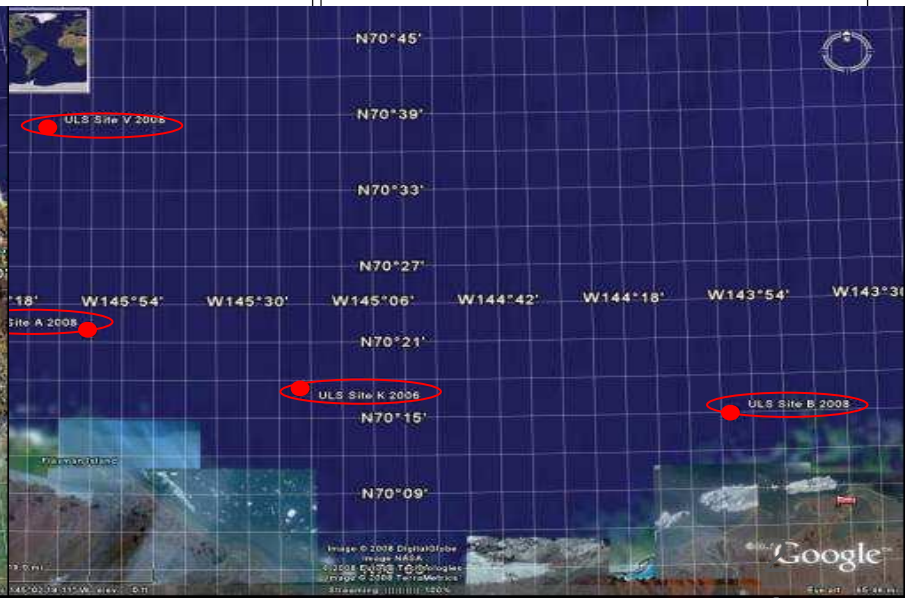
ULS Moorings

Upward Looking Sonars and Acoustic Doppler Current Profilers measure the keel depth and movement of ice. In addition, these moorings measure water currents and open water waves.

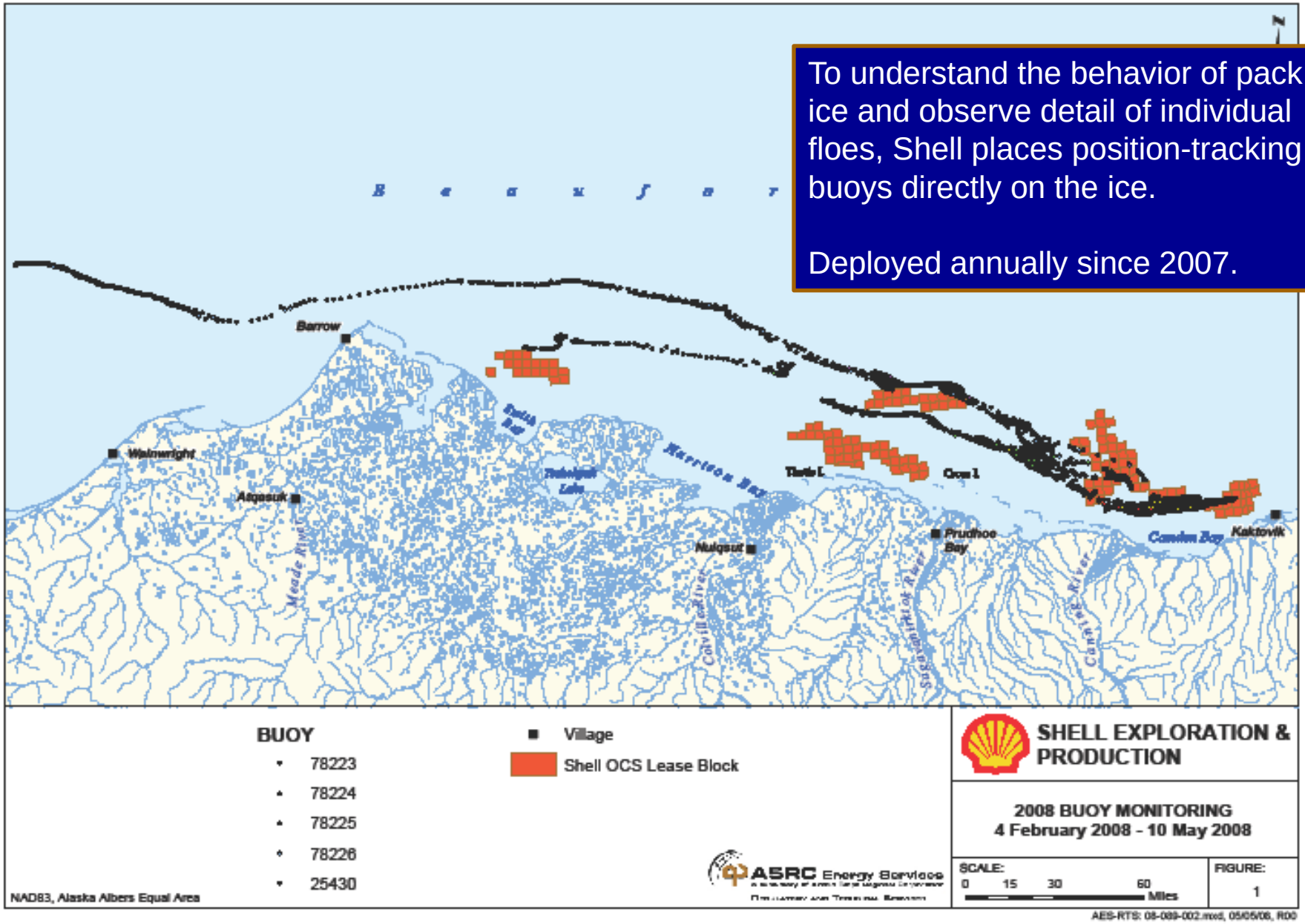
Systems deployed annually since 2005.





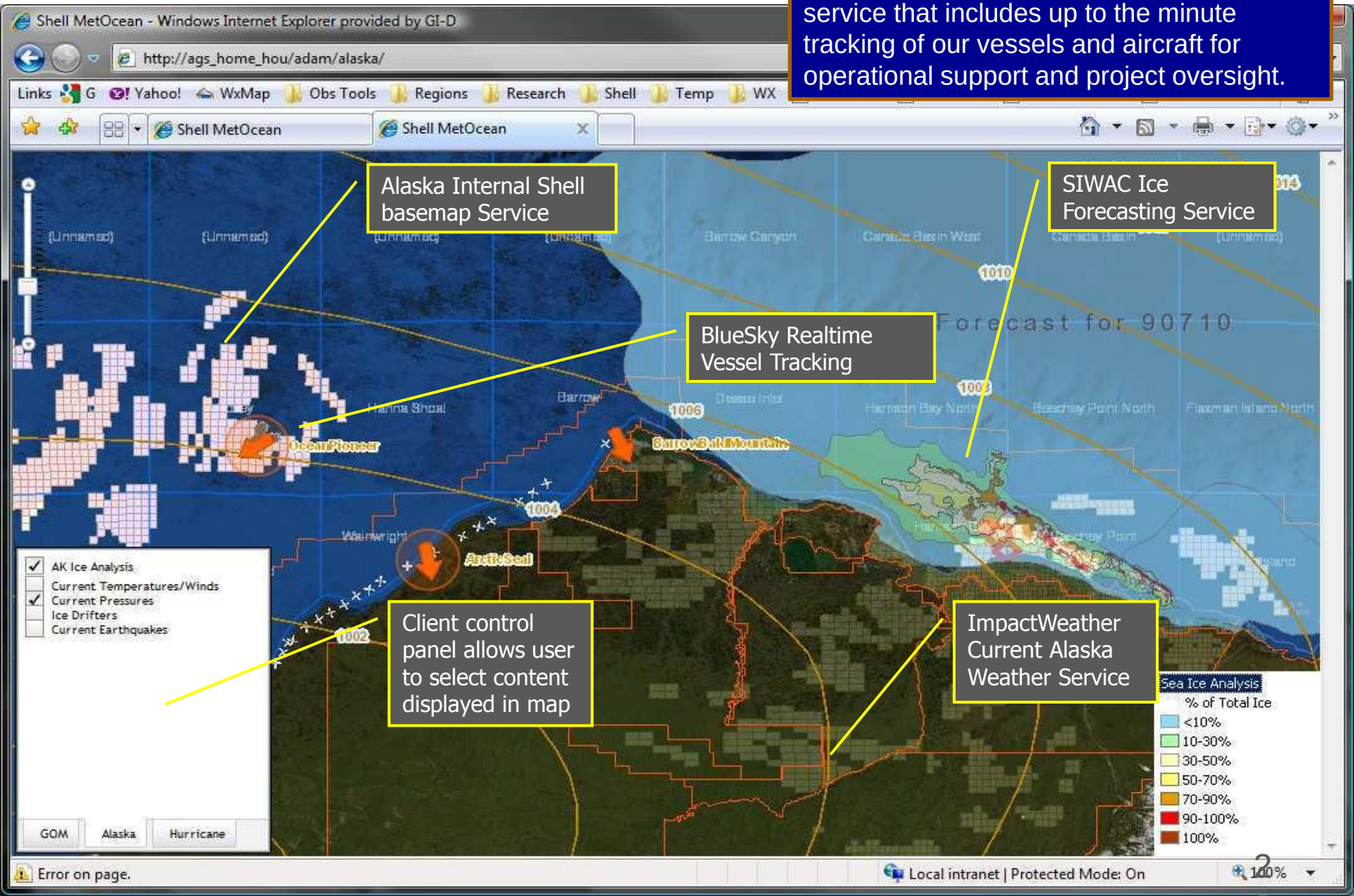


Argos/Iridium Drifters- Measuring ice movement



Pulling it all together…

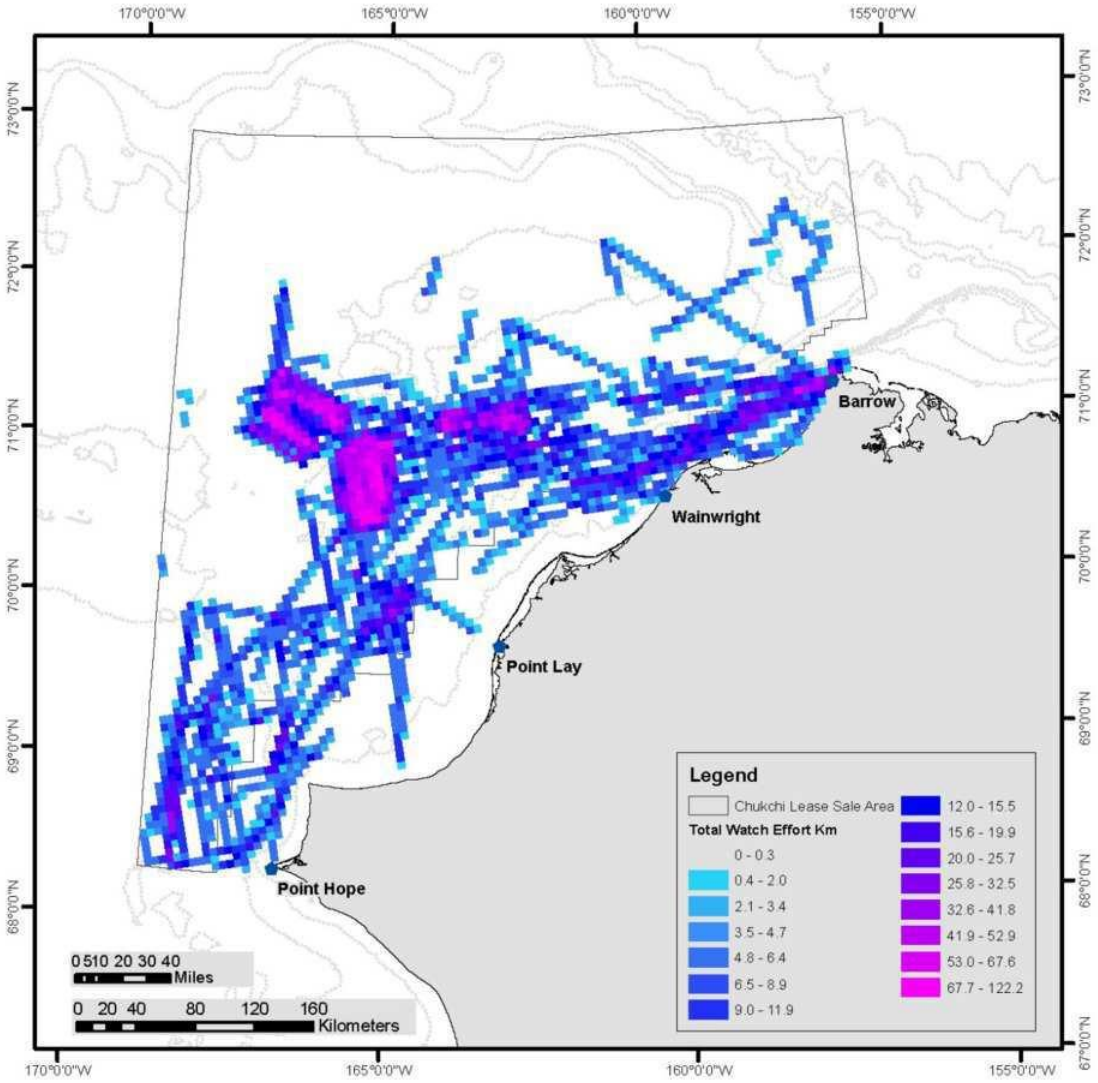
Internally, Shell integrates the ice and weather forecasts into a mapping web service that includes up to the minute tracking of our vessels and aircraft for operational support and project oversight.



Monitoring Program Marine Mammal Observations

Triad of Information

- Vessel based observations
  - Thousands of km of observation in both Chukchi Beaufort
- Aerial observations
  - Programs in both Chukchi & Beaufort
- Acoustics
  - Open water since 2006
  - Year around since 2007



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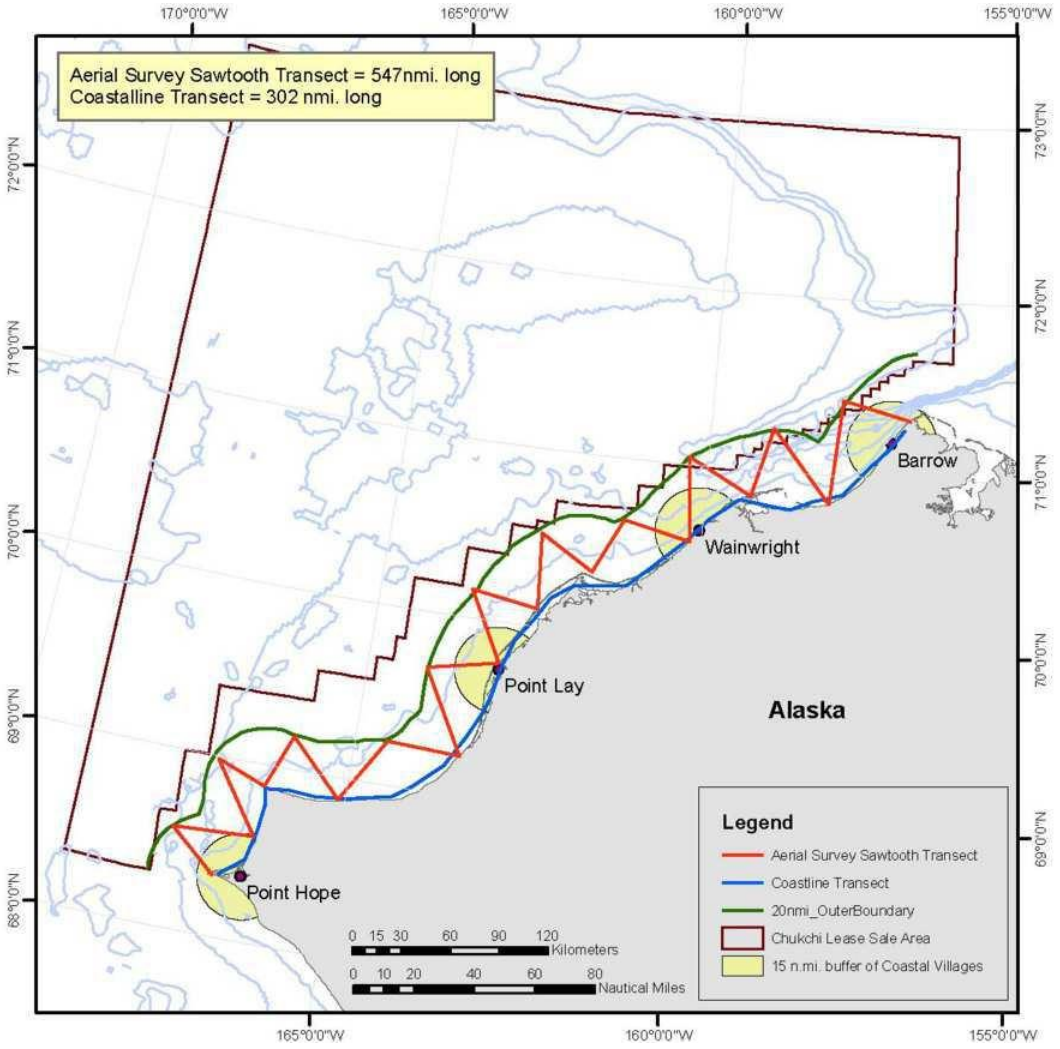

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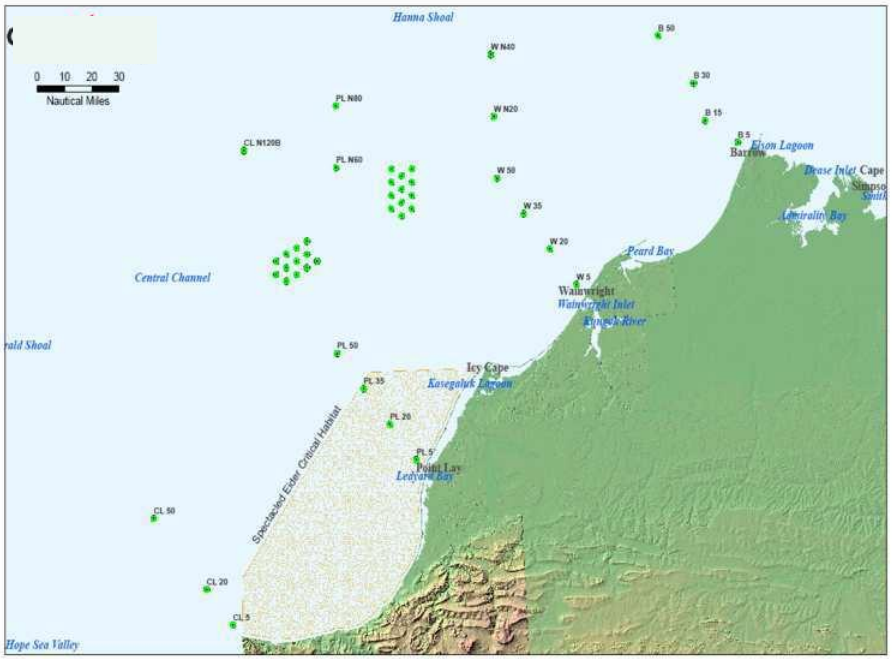
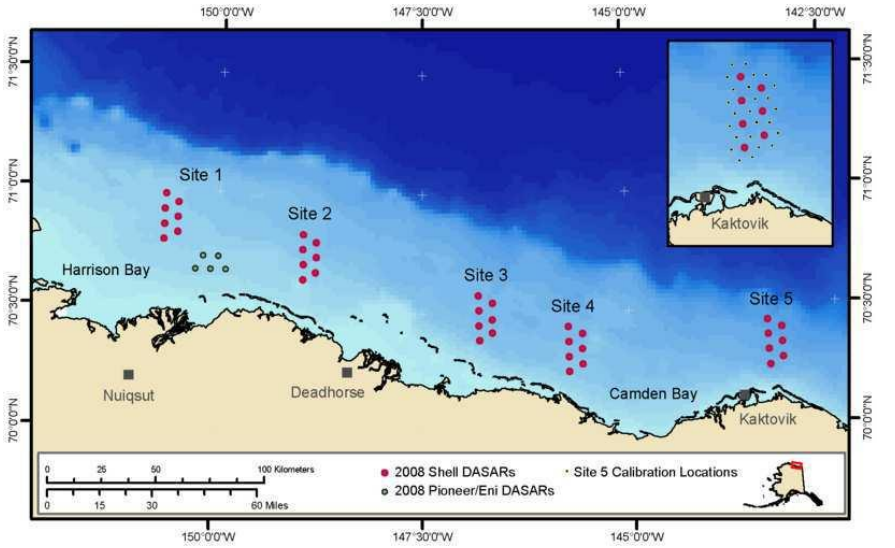
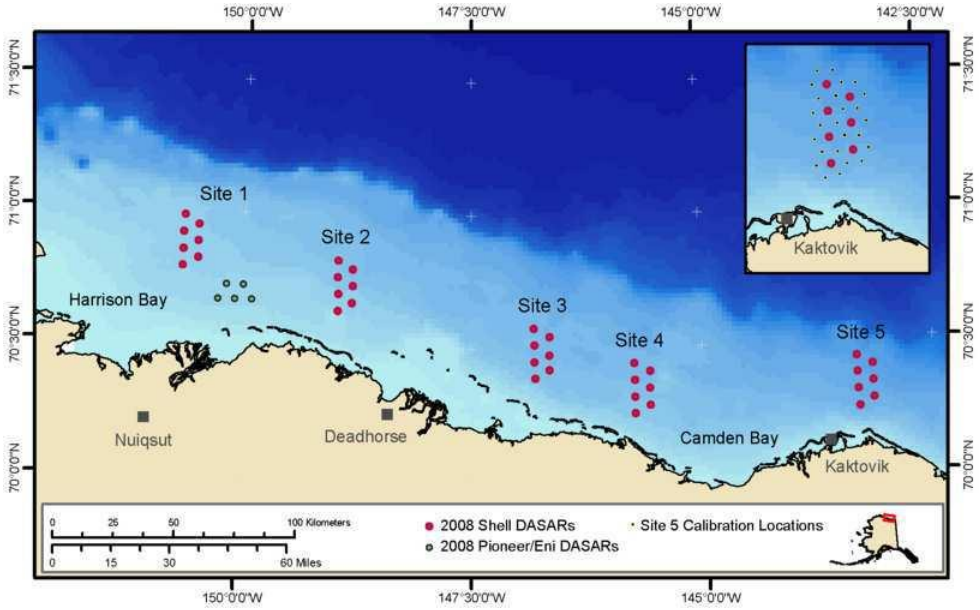
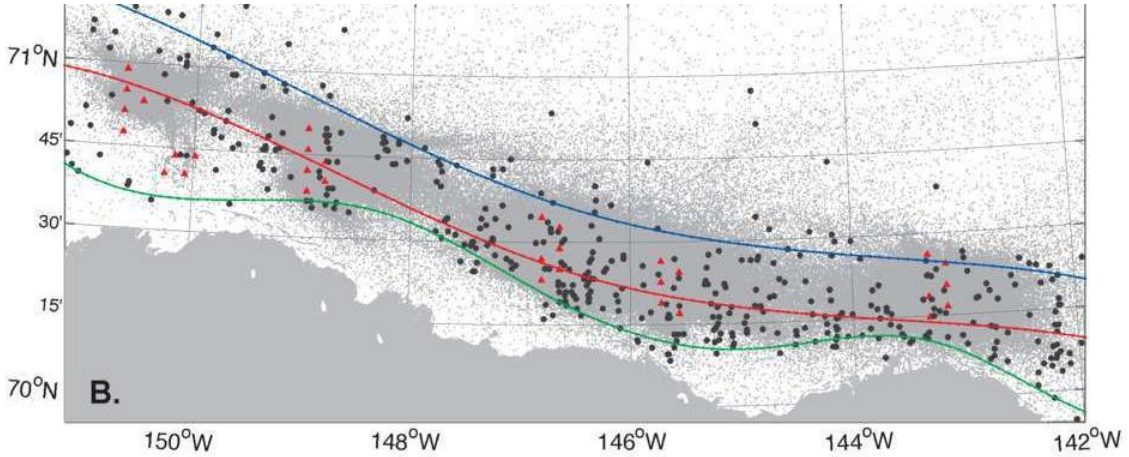




Results – Bowheads, migration, and vocalization

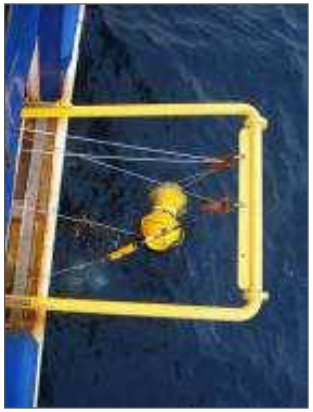
- Acoustic recorders deployed in the Beaufort
- Localization capability
- Major goal to understand effects of industry sound on the distribution and behavior of bowheads.





Ecosystem Approach to Data Gathering in the Offshore – 2008 - 2010

- Joint Program – ConocoPhillips, Shell, & Statoil with Olgoonik-Fairweather & UT
- Integrated Environmental Studies Program – Ecosystem Approach:
  - Marine Mammals
  - Seabirds
  - Zooplankton
    - Nutrients, chlorophyll *a*
  - Benthic Invertebrates
  - Fisheries in 2009 & 2010 only
  - Acoustic Signature
  - Baseline Soils & Biota Chemistry
  - Physical Oceanography
    - Sea temperature, conductivity at various depths
    - Currents
    - Ice Profiling
  - Metocean Data
  - Mid-July - late October



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  - Seabirds
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    - Nutrients, chlorophyll *a*
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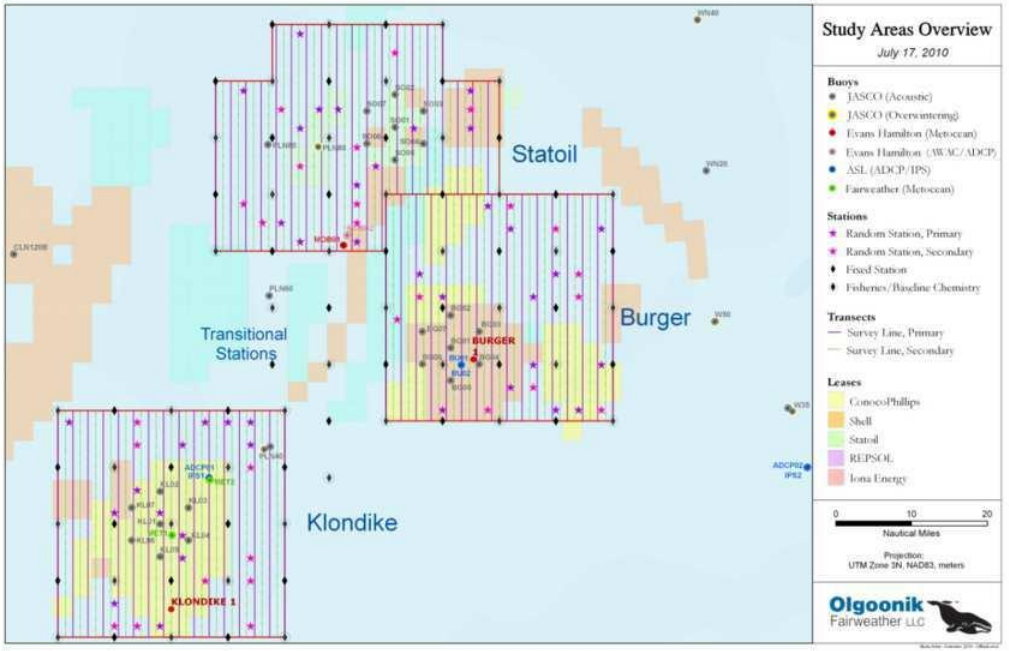
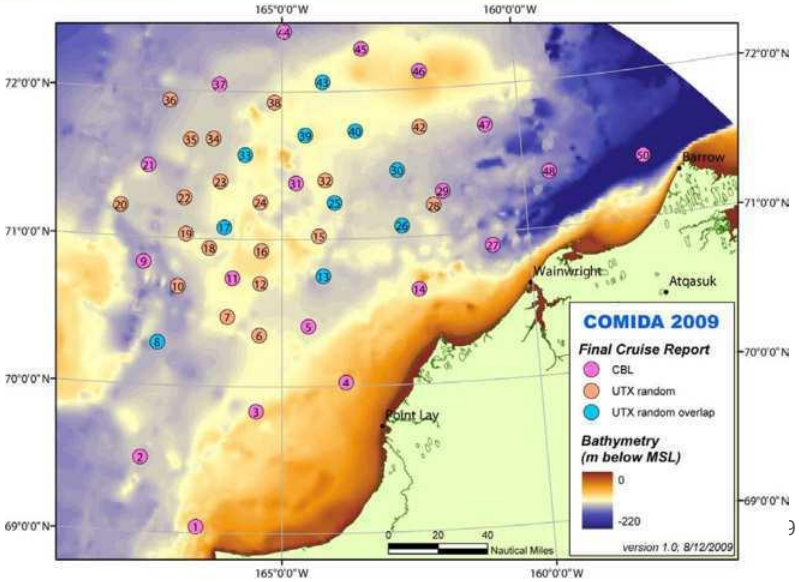
  - Baseline Soils & Biota Chemistry
  - Physical Oceanography
    - Sea temperature, conductivity at various depths
    - Currents
    - Ice Profiling
  - Metocean Data
  - 3 Sample periods
    - Mid-July - late October





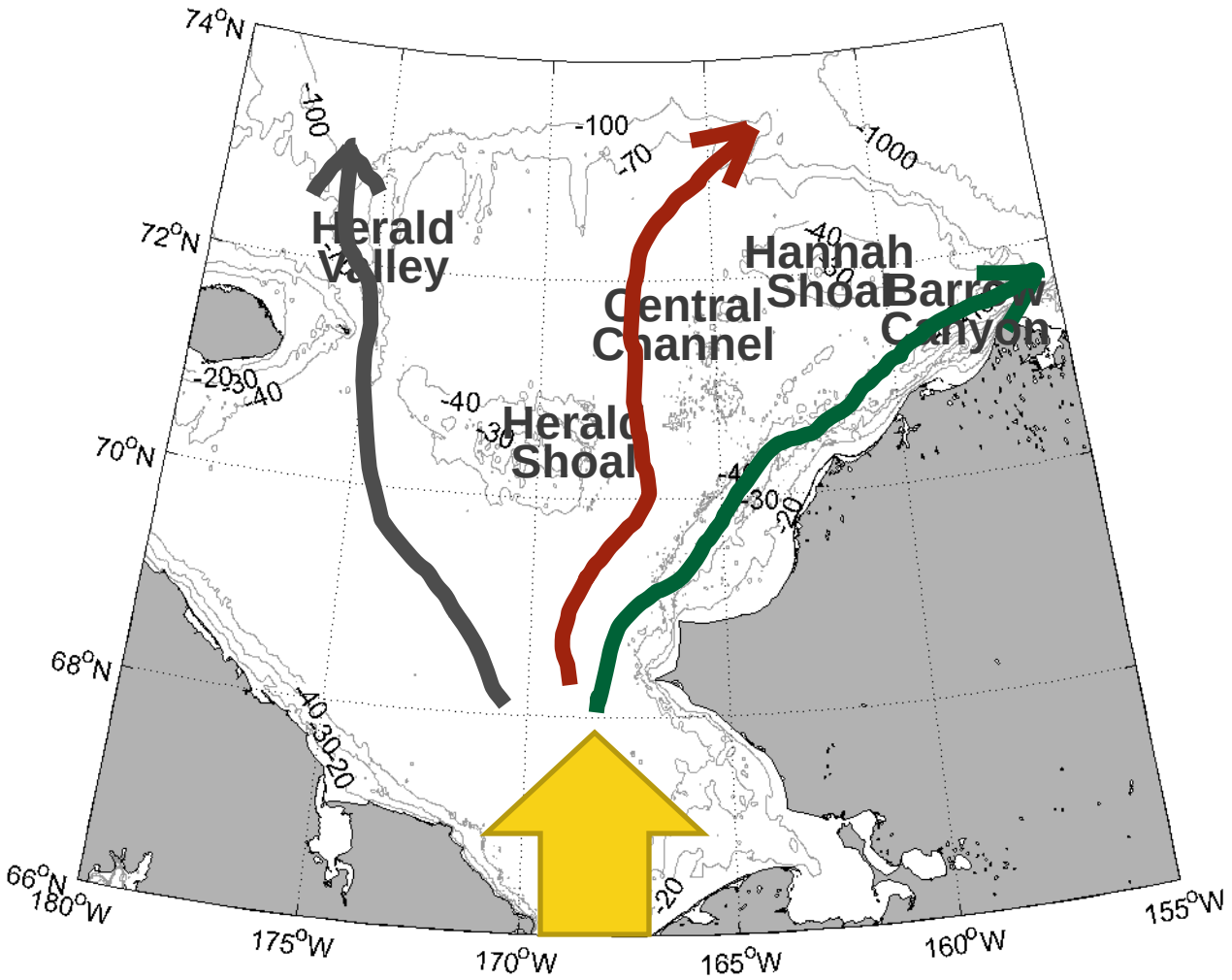
Shell Arctic Oil Spill Response R&D - Examples

- **Objectives**
  - Increase response efficiency while reducing environmental impacts
  - Address stakeholders concerns and implement best practices into operations
  - Collaborate with governmental agencies, industry partners, and academia
- **SINTEF JIP on Oil Spill Response in Ice**
  - Completed 2010: 6 oil companies and Government partners
  - Demonstrated effectiveness of mechanical recovery, in-situ burning, and dispersants in broken ice. Showed extended window of opportunity for Arctic spill response
- **NewFields JIP on Dispersed Oil in Arctic Conditions**
  - Planned for 2011 completion: 4 oil companies
  - Showed Arctic species to have comparable toxicity response to species from temperate regions and demonstrated significant biodegradation rates of dispersed oil
- **OGP JIP on Arctic Oil Spill Response**
  - Initiated 2011: multiple oil companies including Shell
  - Objective is to further advance capability: detection, mechanical recovery, dispersant effectiveness, in situ burning, environmental impacts

Thank You

Results – Currents, topography & ecosystems

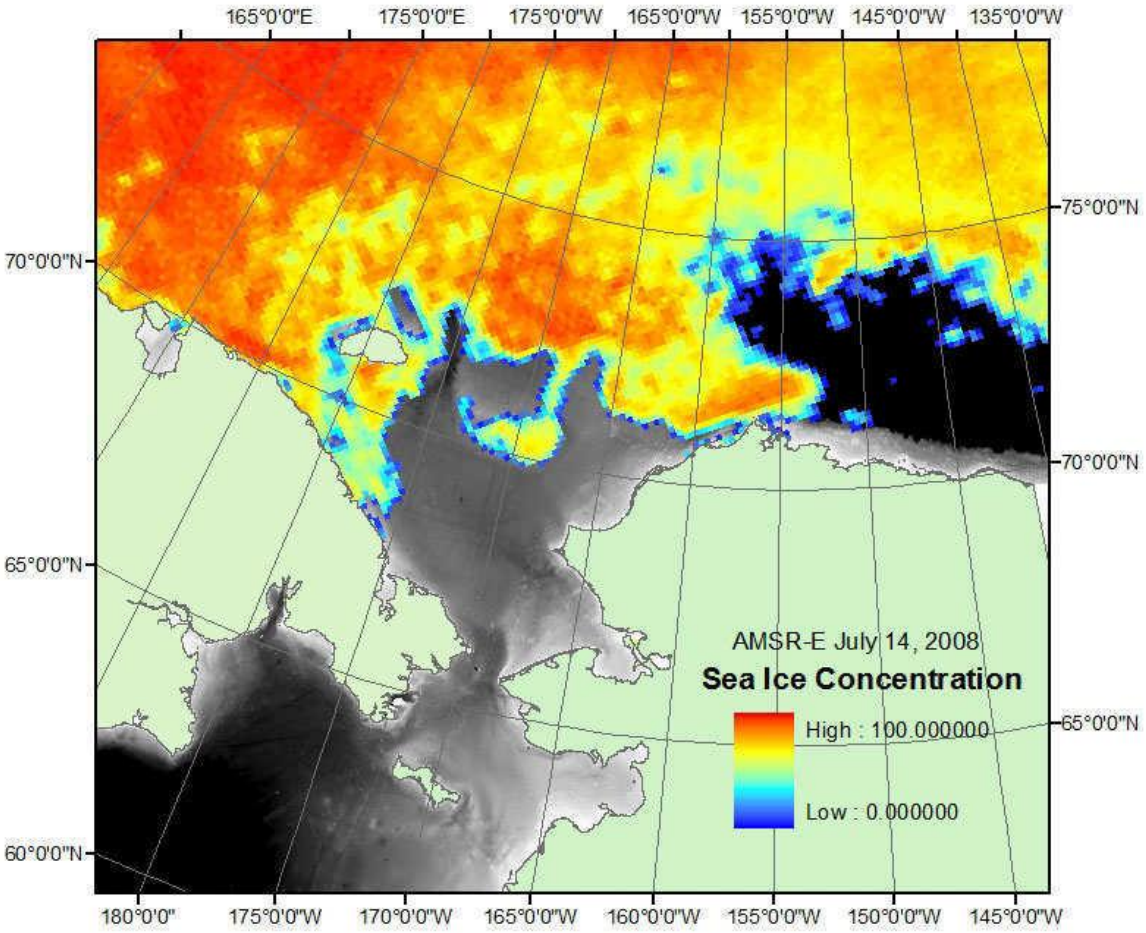
Bathymetry Steers Currents



- Shallow Shoals
- Deeper Canyons and Channels
- Mean northward flow due to pressure gradient from Pacific to Arctic
- Flow field follows the deeper areas

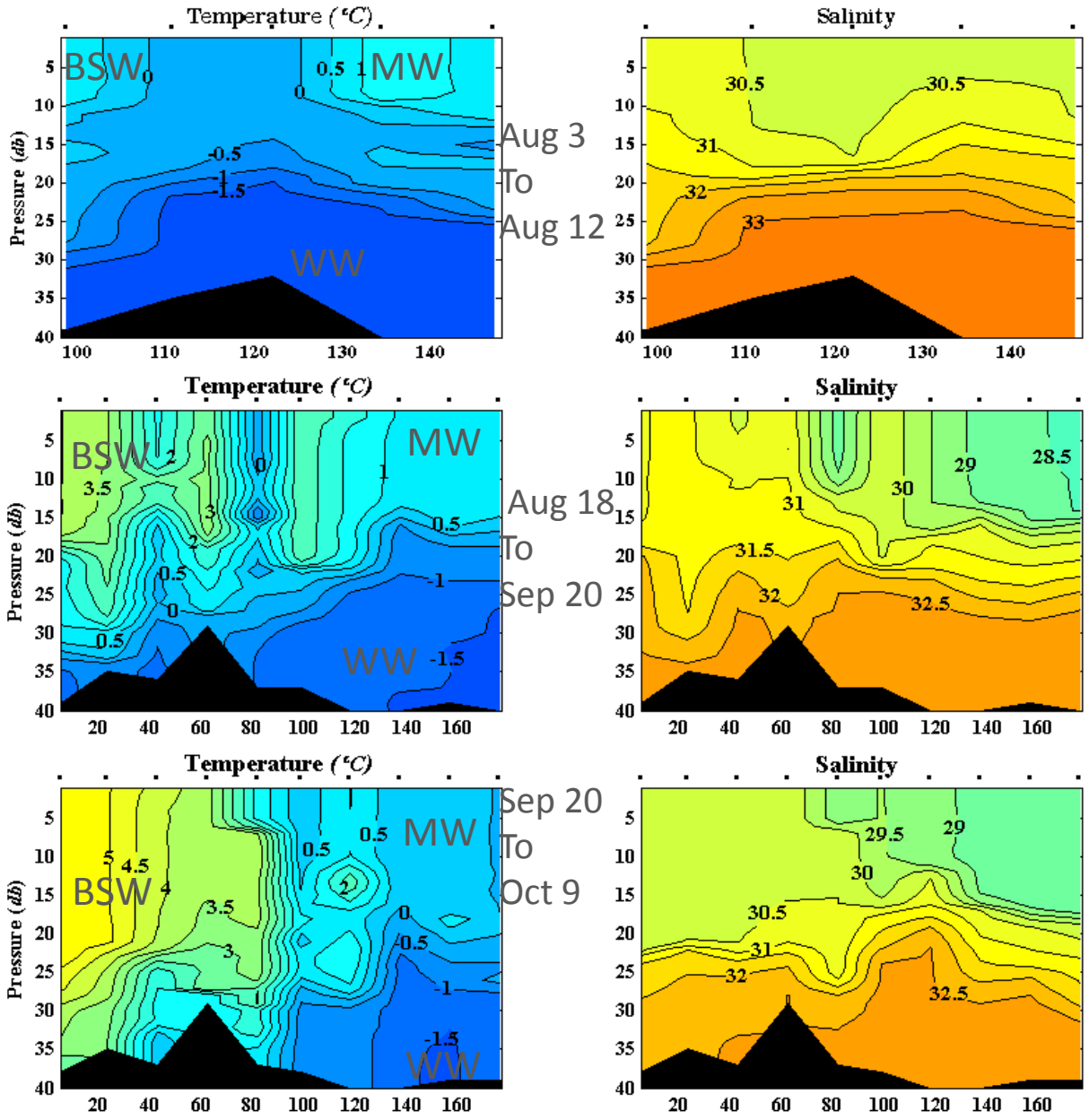
Results – Currents, topography & ecosystems

Currents Effect Ice Retreat



- Ice retreats earliest in channels and latest over shoals

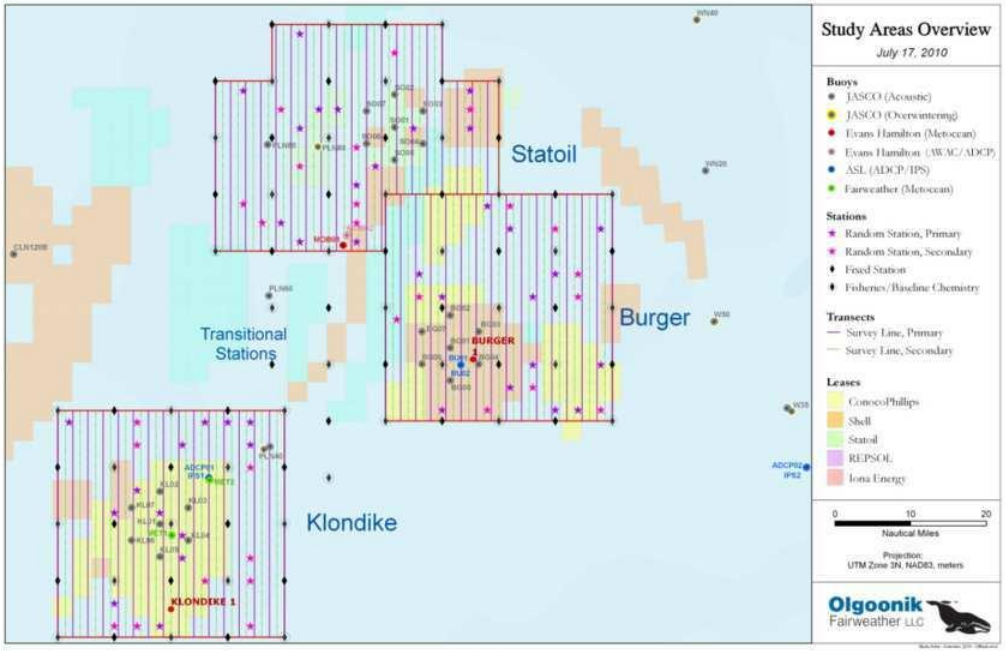
Results – Currents, topography & ecosystems



- Different water bodies
- Temperature gradients
- Salinity gradients
- Differences between areas as close as 15 km

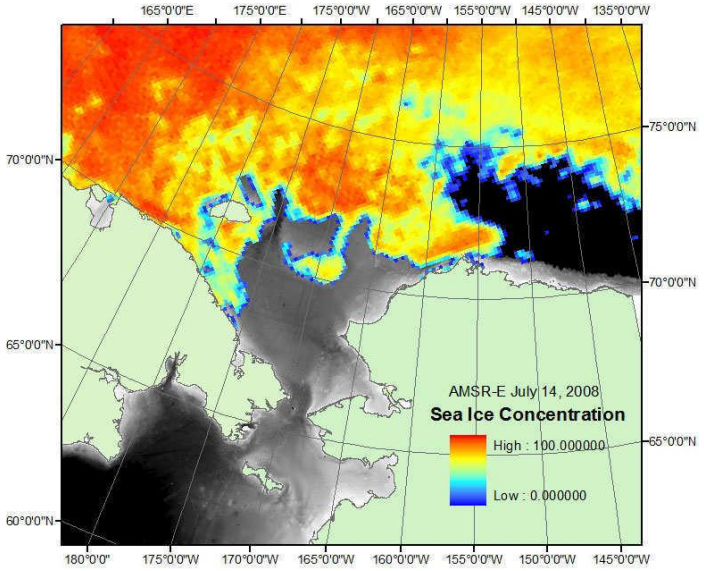
Results – Currents, topography & ecosystems

- Differences reflected both annually and interannualy
- Areas of early melt tend to be pelagicly driven
- Areas if later melt tend to be benthicly driven with higher biomass concentrated in the benthos
- Differences reflected in the marine birds and marine mammals



Results – Walrus and haulouts

- Walruses move into the Chukchi in June and summer until mid September
- Spend open water period feeding in offshore areas
- Generally rest on ice
- ‘07, ‘09, & ‘10 large haul outs have occurred on the Chukchi coast
- ‘09 mortalities occurred

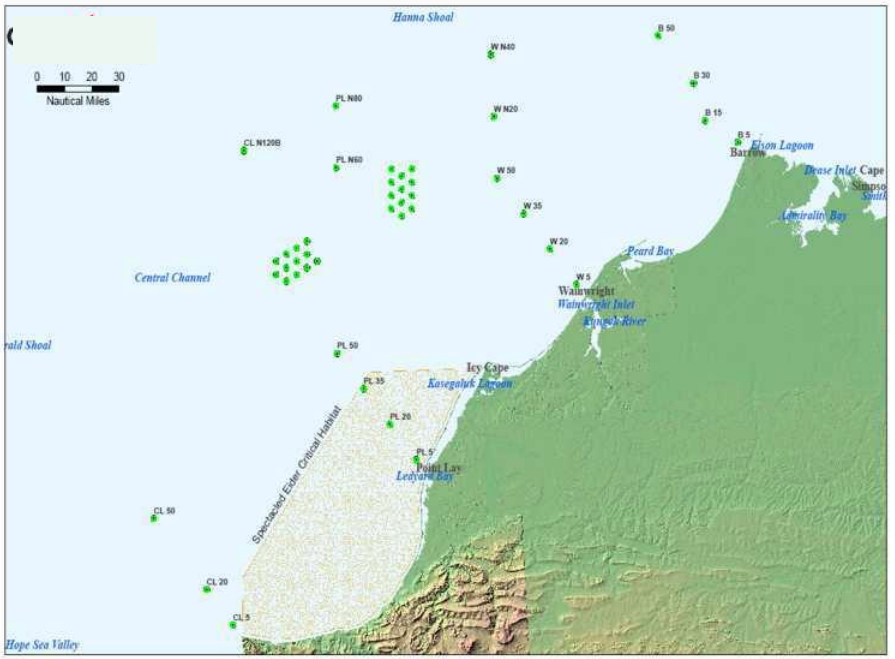


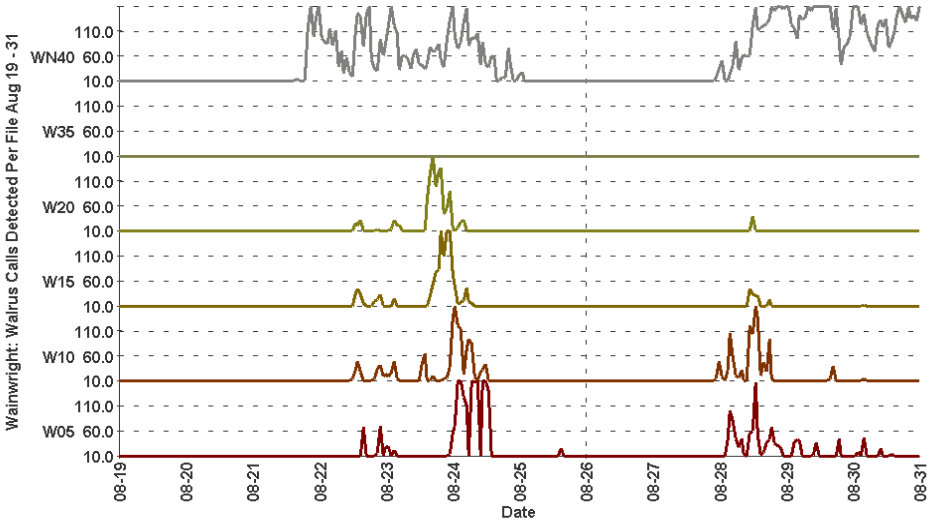
Data to support walrus investigations

- Monitoring data – aerial, acoustic, vessel
- Funded USGS to do tagging studies
  http://alaska.usgs.gov/science/biology/walrus/2010animation_Norseman.html

Results – Walrus and haulouts

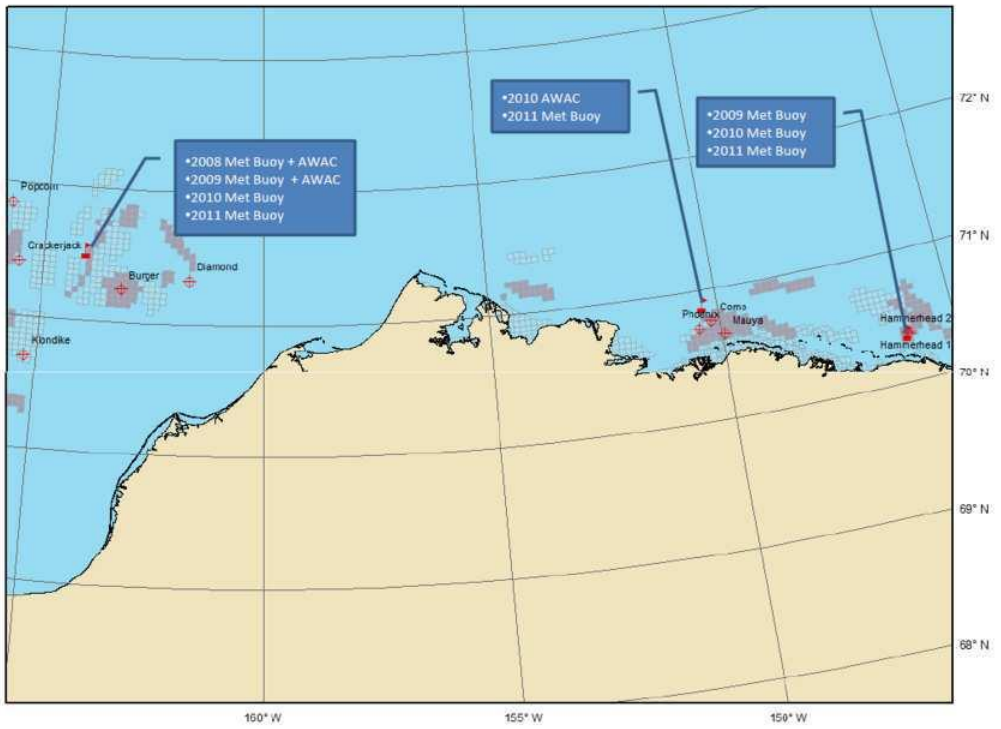
- Pattern that we see over four years of data
- When ice fully recedes above the shelf break
- Walrus stay in the offshore for 14-18 days
- After this time, they are forced to come to onshore haulouts
- Continue to move back to offshore areas periodical





Metocean / Physocean

- Metocean deployments
  - Current profilers
  - Meteorological buoys
- Current mapping
- Ice mapping and studies



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Chukchi Surface Currents
HF Radar

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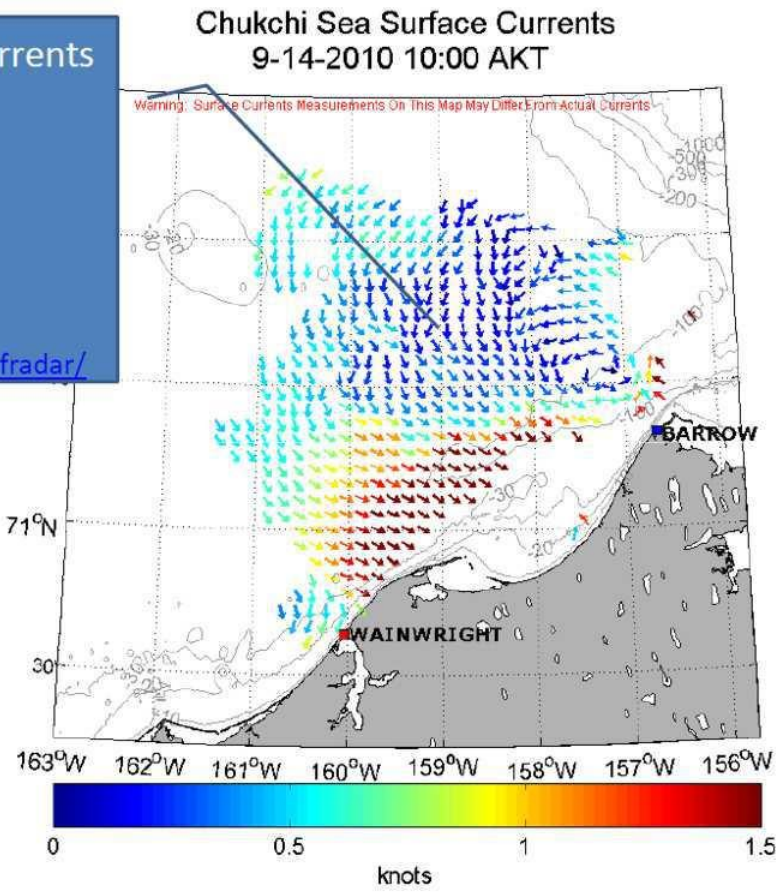

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